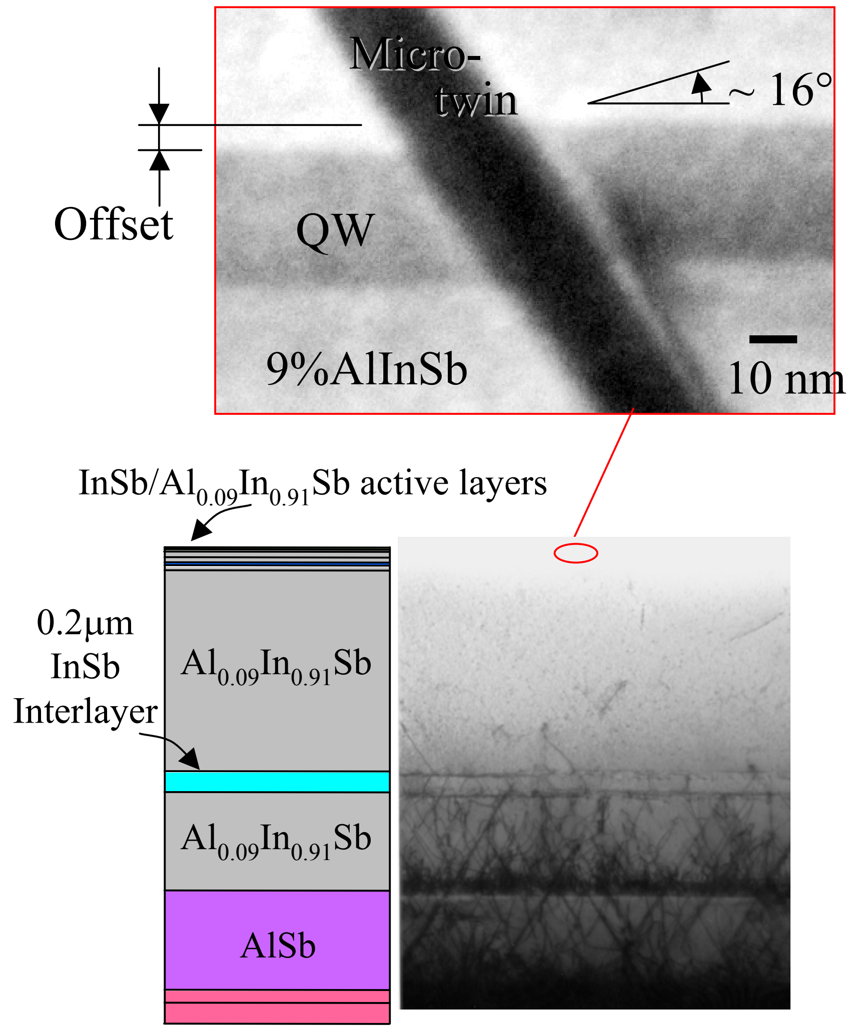
Spin and Other Electronic Properties of InSb Quantum Wells

M.B. Santos, S. Murphy, and R.E. Doezema/U. OK, DMR-0209371

Materials with properties that depend strongly on electron spin can potentially enable new types of electronic devices. One drawback in using InSb-based structures is that there is no lattice matched III-V insulator to serve as a substrate material. Semi-insulating GaAs is used as a substrate material in spite of its large lattice mismatch, which leads to micro-twin defects in the quantum well. Anisotropy in the low-temperature electron mobility correlates with an anisotropic distribution of micro-twins.

We are exploring the effect of buffer layer composition on defect propagation, with the goal of minimizing the defect density in the quantum well layer. The top figure shows a dark-field cross-sectional transmission electron micrograph of a micro-twin crossing an InSb quantum well. The offset induced by the micro-twin reduces the mobility of electrons in the quantum well. The bottom figure shows that the defect density in the active layers can be substantially reduced by insertion of an InSb interlayer during the buffer layer sequence. Through engineering of the strain profile in the buffer layers, the density of dislocations and micro-twin defects in the active layers can be substantially reduced. The effects of simple strained interlayers and more-complicated graded buffer layers are being studied. The improved heterostructures are enabling experiments on electron spin effects in InSb quantum wells and electron transport through mesoscopic InSb devices.



The top figure shows a dark-field cross-sectional transmission electron micrograph of a micro-twin crossing an InSb quantum well. The offset induced by the micro-twin reduces the mobility of electrons in the quantum well. The bottom figure shows that the defect density in the active layers can be substantially reduced by insertion of an InSb interlayer during the buffer layer sequence. We are exploring the mechanisms behind the defect reduction, with the goal of minimizing the defect density. A minimized defect density will facilitate the development of new electronic devices that exploit the small effective mass and strong spin effects of electrons in InSb.

Spin and Other Electronic Properties of InSb Quantum Wells

M.B. Santos, S. Murphy, and R.E. Doezema
University of Oklahoma DMR-0209371

Education:
Six undergraduates and five graduate students contributed to the research performed during the first two years of this grant. In addition to experiments performed on campus, some of the students traveled to the National High Magnetic Field Laboratory (Tallahassee FL) and NTT Basic Research Laboratories (Japan) to perform experiments that required specialized equipment.

Outreach:
Four REU students have participated in this project. During the past year, the PIs have served as judges in elementary and middle school science fairs.

David Deen performed experiments in Japan this summer.

Several experiments were performed at the NHMFL this year.